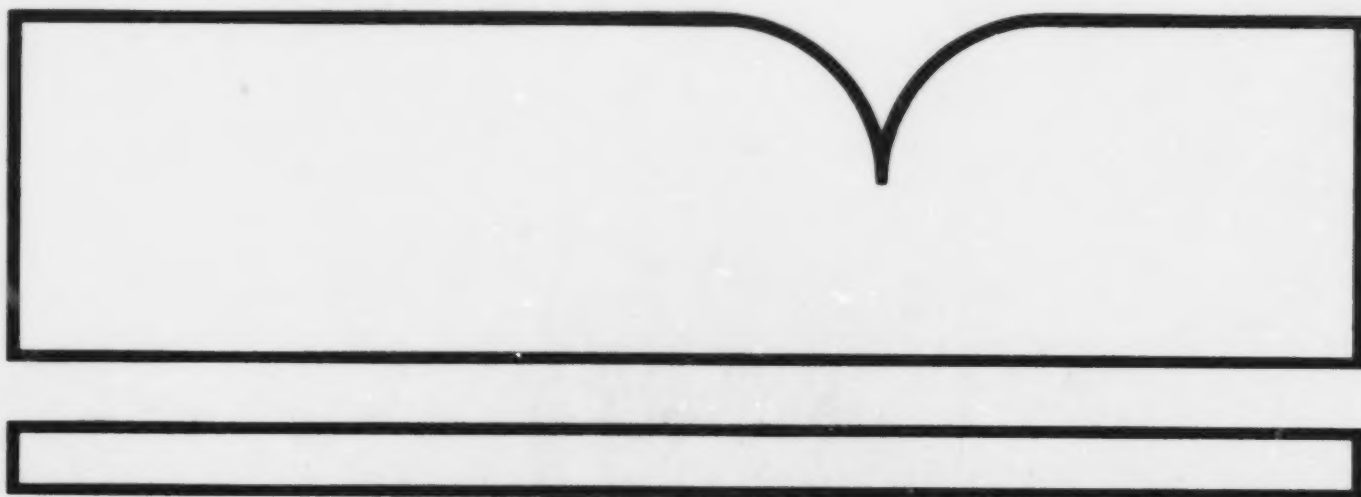


Hazardous Waste Management System: General
Standards Applicable to Owners and Operators of
Hazardous Waste Treatment, Storage, and Disposal
Facilities; and Hazardous Waste Permit Program

(U.S.) Environmental Protection Agency
Washington, DC

Jul 81



U.S. Department of Commerce
National Technical Information Service

NTIS

BACKGROUND DOCUMENT NO. 3

HAZARDOUS WASTE MANAGEMENT SYSTEM: GENERAL;
STANDARDS APPLICABLE TO OWNERS AND OPERATORS
OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL
FACILITIES; AND HAZARDOUS WASTE PERMIT PROGRAM
(40 CFR 260, 264, and 122)

Permitting of Land Disposal Facilities: Land Treatment

This document (ms. 1941.36) provides background
information on EPA's proposed regulations for
land disposal of hazardous waste

U.S. ENVIRONMENTAL PROTECTION AGENCY
July 1981

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No. PD01 24638 1
4. Title and Subtitle Hazardous Waste Management System: General; Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; and Hazardous Waste Permit Programs		5. Report Date July 1981	
7. Author(s) Office of Solid Waste EPA		6.	
9. Performing Organization Name and Address US Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460		8. Performing Organization Rept. No. 1941.33-.42	
12. Sponsoring Organization Name and Address US Environmental Protection Agency 401 M Street, S.W. Washington, DC 20460		10. Project/Task/Work Unit No.	
15. Supplementary Notes		11. Contract(C) or Grant(G) No. (C) (G)	
16. Abstract (Limit: 200 words) Provides background information used in developing performance standards for hazardous waste land disposal facilities. The standards were published in EPA's proposed regulations on February 5, 1981.		13. Type of Report & Period Covered	
		14.	
17. Document Analysis a. Descriptors b. Identifiers/Open-Ended Terms Permitting of Land Disposal Facilities c. COSATI Field/Group			
18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages	
	20. Security Class (This Page)	22. Price	

TABLE OF CONTENTS

<u>INTRODUCTION</u>	Page 4
I. <u>NEED FOR REGULATION</u>	Page 7
II. <u>ANALYSIS OF STANDARDS</u>	Page 8
1. <u>Applicability</u> - §264.270	Page 8
2. <u>General operating requirements</u> - §264.272	Page 10
<u>ISSUE: Surface water run-on and run-off</u>	
3. <u>Waste analysis</u> - §264.273 (Reserved)	Page 13
4. <u>Food-chain crops</u> - §264.276	Page 15
A. <u>Proposed Regulation and Rationale</u>	Page 15
B. <u>Summary of Comments</u>	Page 23
C. <u>Discussion</u>	Page 25
(1)-(9) Response to comments	
(10) Summary	Page 29
D. <u>Regulatory Language</u>	Page 35
5. <u>Unsaturated zone (zone of aeration)</u>	
<u>monitoring</u> - §264.278	Page 37
<u>ISSUE: "Soil and soil-pore water monitoring"</u>	Page 37
A. <u>Proposed Regulation and Rationale</u>	Page 37
B. <u>Summary of Comments</u>	Page 39
(1) Soil monitoring vs ground-water monitoring	
(2) Soil monitoring	Page 41
(a) Sampling procedure	
(b) Depth of sampling	Page 42
(c) Corrective action	Page 43
C. <u>Discussion</u>	Page 45
(1) Soil Monitoring vs Ground-water Monitoring	
(2) Soil Monitoring	Page 46
(3) Summary	Page 52
D. <u>Regulatory Language</u>	Page 53
6. <u>Recordkeeping</u> - §264.279	Page 54

7.	<u>Closure and Post-closure</u> - §264.280	Page 56
A.	<u>Proposed Regulation and Rationale</u>	Page 56
B.	<u>Summary of Comments</u>	
	(1) Return of soil to preexisting condition.	Page 58
	(2) Use of the Extraction Procedure (EP) on soil.	Page 58
	(3) Soil removal: closure as a landfill.	Page 59
	(4) Suggested alternative closure requirements.	Page 59
C.	<u>Discussion</u>	
	(1) Return of soil to preexisting condition.	Page 60
	(2) Use of the Extraction Procedure (EP) on soil.	Page 61
	(3) Waste removal: closure as a landfill.	Page 62
	(4) Alternative closure approaches.	Page 63
D.	<u>Regulatory Language</u>	Page 65
8.	<u>Special Requirements for;</u>	
	<u>Ignitable or Reactive Wastes</u> - §264.281	
	<u>Incompatible Wastes</u> - §264.282	Page 67
9.	<u>Special Requirements for</u>	
	<u>Classes of Facilities</u> - §264.283	Page 71
III.	<u>REFERENCES</u>	Page 73

INTRODUCTION

Requirements for land treatment facilities (formerly called landfarms) were proposed on 18 December 1978 (43 FR 58946-59028). Numerous comments were recieved on that proposal at public hearings and as written comments. A summary of the comments and Agency responses, pertinent to the Part 264 regulations, is presented in Part II of this document. The reader is also referred to two other background documents:

- (1) Background Document, Section 250.45-5, Standards for Landfarms (Land Treatment Facilities), U.S. EPA, Office of Solid Waste, December 15, 1978.
- (2) Background Document, Section 265.270, Final Interim Status Standards for Land Treatment Facilities, U.S. EPA, Office of Solid Waste, April 30, 1980.

In the 30 April 1980 background document, under the heading "Changes in Terminology" the Agency discussed the basis for adopting the term "Land Treatment Facility" in place of "Landfarm". In this discussion, the Agency also set forth its philosophy with respect to land treatment as a waste management technique. That discussion is supplemented below.

The basic philosophy of the agency is that the application of hazardous waste to the soil is a waste management practice reserved for those waste streams that are treatable in a soil system. Although the Agency has a good general understanding of what types of wastes or when wastes should or should not be land treated it has been difficult to translate that understanding into an acceptable regulation to cover all types of wastes and facility designs and

operating procedures which may be used in land treating wastes. The problem is how to specify which wastes may or may not be land treated under what circumstances and to clarify what constitutes treatment. Questions which arise include the following:

- ° How much of the waste must be treatable and how is this to be measured?
- ° Should the regulations distinguish between the treatability of the organic fraction versus the inorganic fraction; between the factors which caused the waste to be classified as hazardous versus other factors?
- ° How much organic degradation is enough to qualify for land treatment?
- ° How much should be known about degradation byproducts and their mobility, toxicity, or degradability?
- ° How much less mobile or less toxic is sufficient and how are these to be measured?
- ° Should reversible immobilization reactions be considered treatment?

Even though many of these questions remain unanswered, the Agency supports the position that the principal objective of land treatment is the biological and chemical degradation of organic waste constituents (See 45 FR 33205). The Agency maintains that land treatment should be, as the name implies, reserved for those wastes that can be treated in a soil system. Although not yet able to define treatment qualitatively or quantitatively for regulatory purposes, the Agency considers treatment at land treatment facilities to include the biological and chemical degradation of

1

organic wastes, the neutralization of wastes that have high or low pH (i.e., corrosive wastes), and the relatively irreversible conversion of inorganic constituents to a less mobile or less toxic form.

The Agency acknowledges that land treatment consists of both treatment and disposal. For example, some metals may be immobilized in the soil and are in that sense treated; these metals also persist in the soil (i.e., do not degrade) and are in that sense disposed. The Agency feels that the greater the degree of treatment a waste undergoes in the soil the more acceptable that waste is for land treatment. A waste which contains a principal component that is irreversibly degraded, irreversibly neutralized, made less mobile, or made less toxic, is considered to be an ideal candidate for land treatment.

The Agency does not believe, except in special cases (e.g., neutralization of corrosive wastes, or where it is known that essentially irreversible chemical reactions occur), that land treatment is the appropriate method of waste management for hazardous wastes that are primarily inorganic in composition (e.g., electroplating sludges, inorganic pigment sludges). In most cases, such wastes can best be managed by alternative methods.

Along the same lines the Agency does not consider using the soil solely as a filtration or dilution medium as an acceptable land treatment practice. Filtration and dilution provide little or no net reduction in hazard if they do not alter the chemical state of the waste.

7

It is evident from the preceding discussion that developing a standard which satisfies the land treatment objective by generically screening wastes is not yet possible. Until many of the questions raised in this discussion can be answered the determination of whether or not a waste is suitable for land treatment will be left to the discretion of the owner or operator of the land treatment facility and the permit issuing authority.

Although an owner or operator may misuse this discretion, there is an incentive, independent of Agency or state review, that encourages the reasonable use of discretion. The incentive is the reduced long-term liability, which can be achieved by land treating wastes that undergo a high degree of treatment in the soil (e.g., wastes that are composed of predominantly degradable organics, or wastes that are hazardous due solely to high or low pH). Land treating such wastes could substantially reduce the post-closure care responsibilities of §264.117(d) and therefore the costs associated with post-closure care. Reduction of the post-closure care responsibilities would be contingent upon the owner or operator demonstrating that the waste, and any byproducts of degradation that are of concern, have been treated and rendered innocuous.

I. NEED FOR REGULATION

The need for regulation of land treatment facilities has been covered in the background document "Subpart M - Interim Status Standards of Land Treatment Facilities" dated 30 April 1980. The basis for the need to regulate land treatment facilities presented in that document does not need to be supplemented to support the general status regulations being proposed.

(8)

II. ANALYSIS OF STANDARDS

1. Applicability - §264.270

A. Proposed Regulation and Rationale

The applicability of the proposed standards was discussed in the preamble to proposed December 18, 1978 regulation (Hazardous Waste, Proposed Guidelines and Regulations and Proposal on Identification and Listing, 43 FR 58982). Applicability was further delineated by the definition of land treatment, then referred to as landfarming. Land treatment was defined as the application of waste onto land and/or its incorporation into the surface soil, including the use of such waste as a fertilizer or soil conditioner.

B. Summary of Comments

N/A

C. Discussion

The Part 264 land treatment regulations contain a specific applicability standard which differs from the standards proposed in December 1978 primarily in that the term (landfarm) applied to the practice has changed. The definition a of land treatment facility applicable to interim status has been amended to reflect the fact that waste may or may not remain in place after closure. As proposed, the definition of a land treatment facility in Part 260 of the regulations reads as follows; "Land treatment facility means a facility or part of a facility at which hazardous waste is applied onto or incorporated into the soil surface.

The practice has been further described in the preamble to Types of facilities - §264.19(a) as follows; "Land treatment facilities are facilities at which waste; usually in a solid,

(9)

semi-solid, semi-liquid, or liquid state; are spread on the surface of the ground for the purpose of treatment. Discharge to the groundwater normally occurs as leachate. Discharge to the surface waters normally occurs both by erosion and as leachate mixed with ground water. Discharge to the atmosphere normally occurs as diffuse gaseous emissions. Wastes are nearly always left in place at closure."

This description not only encompasses the definition by describing in a physical sense the practice of land treatment, it also describes the: purpose of land treatment, physical nature of the wastes that are land treated, mechanisms by which discharges may occur, media affected by the discharges, and the ultimate fate of the wastes upon closure of the facility.

The most significant aspect of this description is the statement that the purpose of land treatment is treatment. Discussion on this Agency attitude is presented in the introduction to this document and in the preamble to these regulations at 46 FR 11144-45. The bottom line of the discussion is that the Agency considers land treatment to be a waste management practice reserved for those waste can be successfully treated in a soil system. Although this interpretation of land treatment has been difficult to translate into qualitative and quantitative terms, the Agency's objective is to encourage the efficient use of the soil as a treatment medium while discouraging irresponsible parties from characterizing indiscriminate dumping of waste as land treatment. The Agency acknowledges that not all of the constituents of a waste will be treated, e.g., degraded, immobilized, detoxified or neutralized.

10

Some waste constituents will inevitably persist in the soil and in that sense are disposed. The fact that disposal occurs due to residuals being present in the soil in which treatment occurs, as well as due to liquid migration and gaseous emissions, is reflected in the portion of the land treatment description which states that "wastes are nearly always left in place at closure."

D. Regulatory Language

The regulations in this Subpart apply to owners and operators of hazardous waste land treatment facilities, except as §264.1 provides otherwise.

2. General operating requirements - §264.272

ISSUE: Surface water run-on and run-off

A. Proposed Regulation and Rationale

Requirements for control of surface water run-on and run-off were proposed under §250.43 (b) and (c). Those regulations would have required the owner or operator to construct diversion structures capable of preventing run-on from entering a land treatment facility. A variance to this requirement was allowed where an owner or operator could demonstrate to the Regional Administrator that run-on would not enter the site and come in contact with the hazardous waste. The regulations would also have required the owner or operator to collect and confine run-off from active portions of the facility to a point source before discharge or treatment.

B. Summary of Comments

See the 30 April 1980 background document, which references comments presented in the background document "Subpart N - Interim Status Standards for Landfills" dated 2 May 1980.

C. Discussion

The requirements under the general status regulations are equivalent to the requirements under interim status. The comment to the interim status requirements has been deleted.

In the Part 264 regulations land treatment facilities are subject to the same requirements as landfills regarding surface run-on and run-off. Run-on must be diverted away from the active portions of the land treatment facility. Run-off from the active portions must be collected. If the collected run-off is a hazardous waste it must be managed as a hazardous waste. If the run-off is not a hazardous waste but it is allowed or caused to infiltrate the land on site, it will have to be permitted as a leachate discharge. If the run-off is not a hazardous waste and it is to be otherwise removed from the site, it may still need to be analyzed, treated, or otherwise managed to comply with Subtitle D of RCRA or the Clean Water Act.

EPA believes that run-on and run-off controls are necessary at land treatment facilities because this disposal option involves the placement of hazardous waste on or just beneath the soil surface. Because the waste is exposed during the application and incorporation process, the potential for loss via surface water erosion is initially high. During site operation, the potential for run-off to become contaminated is directly related to the frequency and rate of waste application. In the long term, the potential for run-off to be contaminated is further increased as refractory waste contaminants becomes concentrated in the surface soil.

The release of dissolved or suspended waste contaminants or contaminated sediment from a land treatment facility can have adverse human health and environmental effects. One damage case, involving contamination of a lake by run-off from an oily waste land treatment facility, has already been documented (1). At another oily waste land treatment site in Texas, surface run-off from experimental plots were found to contain 30-100 mg/l of oil (2). The study concluded that "oil and nutrient contents of the rainfall run-off water from the soil cultivation [land treatment] process can be relatively high, and this discharge water should receive treatment before entering public waterways." This conclusion was supported by another study which cited the low tolerance of aquatic organisms to certain trace elements as the major reason for controlling run-off (3).

The Agency acknowledges that the surface area of the active portions of a land treatment facility will generally be large, relative to the active portions of landfills. Consequently, more extensive run-on diversion structures and run-off collection systems will be needed at land treatment facilities. The overall impact of run-on and run-off controls is expected to be somewhat tempered since most land treatment facilities already have diversion structures and collection systems (4). The Agency does not anticipate that all the run-off that is collected at land treatment facilities will require treatment prior to discharge. Evidence in the literature suggests that if the waste is thoroughly incorporated into the soil, contamination of run-off can be minimized or prevented. At an oily waste land treatment facility in Texas, it

was found that after thorough waste incorporation, there was no significant difference between the quality of run-off from experimental and control plots (5). Agricultural pesticide run-off studies have shown that run-off quality improves with the length of the storm event and with the length of time since the last pesticide application (3). These phenomena are paralleled in land treatment facilities.

These studies strongly suggest that run-off may need treatment only during certain periods, for example, run-off that is collected at the beginning of a storm event or immediately after waste has been applied. Once wastes have been incorporated into the soil, and the wastes have been degraded or the soil surface stabilized by crusting or vegetation, collected run-off is expected to require little or no treatment.

D. Regulatory Language

(a) Run-on must be diverted away from the active portions of a land treatment facility.

(b) Run-off from active portions of a land treatment facility must be collected.

3. Waste analysis - §264.273 (Reserved)

A. Proposed Regulation and Rationale

The waste analysis requirements in §250.43 of the proposed regulations applied waste analysis to all treatment, storage, and disposal facilities, including land treatment. The waste analysis requirements included: determination of the hazardous constituents and properties of the waste prior to initial disposal; verification of certain properties of each waste shipment received; and periodic,

comprehensive analysis of waste if there were indications of changes in composition.

The reasoning behind the proposed recordkeeping requirement was discussed in the background document on waste analysis. In brief, the purpose was to ensure that a facility owner or operator had sufficient current information to manage the waste without endangering human health and the environment.

B. Summary of Comments

Comments on the proposed waste analysis requirements are discussed in the May 1980 Background Document on Waste Analysis.

C. Discussion

The requirements for Waste Analysis have been deleted because this section was thought to be redundant with the requirements under §264.13, General waste analysis, and the information requirements of §122.25(d). An owner or operator is required under §264.13 to analyze the waste to the extent necessary to land treat the waste, and under §122.25(d) to define the hazardous waste(s) that will be land treated and predict the mass rate of hazardous waste and decomposition byproducts that are expected to leach or otherwise escape from the site.

Given these requirements and the comprehensive waste analyses needed to comply with them, the Agency felt the waste analysis requirements of §264.273 were unnecessary.

The above discussion is reproduced from the preamble at 46 FR 11145 correcting an error referencing §264.21 instead of §122.25(d).

D. Regulatory language

N/A

4. Food-chain crops - §264.276

A. Proposed Regulation and Rationale

The proposed regulations prohibited growing of food-chain crops on the treated area of a land treatment facility. The purpose of the proposed regulations was to protect humans from consuming toxic materials that may contaminate human or animal food grown on land to which hazardous waste has been applied.

Several routes exist by which food-chain crops grown on land treatment facilities may be contaminated by hazardous waste constituents. These are: uptake by plants of the hazardous constituent from the soil, and transfer to the edible portion of the plant; adherence of a waste to crop surface; and ingestion of the waste by grazing animals.

There are many factors which influence the degree to which various hazardous constituents may be transferred along these routes. These include: the chemical, physical, and biological characteristics of the waste; the method of application; the rate of application; season; climate; soil characteristics (including soil type, moisture content, pH, cation exchange capacity of the soil (CEC), hydrous-oxide content, and biological and microbiological activity); the type of crop grown; the method of planting; time and method of harvest, etc.

The information available on the extent to which organic or inorganic substances are actually translocated to crops is limited. Many of the studies which have been done are the subject of a great deal of controversy. For example, many studies failed to include pH effect on metal accumulation, thus the knowledge of pH

effect on metal accumulation is insufficient. Also, there are varying opinions on the validity of extrapolating greenhouse data to represent actual field conditions.

In addition to the difficulties involved with predicting and controlling the various factors which influence the transfer of hazardous constituents to food-chain crops, there is only limited information available regarding "safe" levels of various substances in crops. Although the Food and Drug Administration expresses concern about the growing of food-chain crops on waste amended soils, no qualitative or quantitative guidance, except for PCBs*, has been given as to what levels of toxic metals or other hazardous constituents in crops would protect human health.

Also, presentations in the literature on this subject do not always clearly distinguish plant toxicity from animal toxicity. It is recognized that toxic effects to crops can provide some protection for crop consumers (animal and human). However, accumulation of hazardous constituents in crops without signs of plant toxicity creates the opportunity for human exposure to potentially harmful substances. The reported levels of hazardous constituents in crop tissues are sometimes misinterpreted. Care is not always taken to distinguish between data on the edible and nonedible portions of the crop. However, even the "nonedible" portions of the crop may be used for animal feed so that a particular hazardous constituent may still enter the food chain. Also, nonharvested portions of the crop may remain in the soil where the

* Finished animal feeds are the only crops for which FDA has set a PCB tolerance level. This tolerance level is 1.2 ppm in feeds that are given to animals consumed by humans.

hazardous constituents could remain and become available for subsequent uptake.

While the state of knowledge about translocation of hazardous constituents to crops is incomplete, the Agency does have information to suggest that there is a significant cause for concern that translocation of some of the hazardous constituents to food crops could endanger public health.

The cause of the Agency's concern regarding growth of food-chain crops on land treated with waste is exemplified by a variety of actual incidents, studies, and projections. It should be noted that although many of the incidents described here do not relate specifically to land treatment of hazardous wastes, the concerns they raise are still pertinent to this program. The concerns relate to ingestion by animals, vaporization or direct adherence to crops, and plant uptake.

It is known, for example, that almost any hazardous waste could be metabolized through direct ingestion by grazing animals. Soil is ingested by grazing animals along with herbage from the adhering to leaves, from soil on roots, and from earthworm casts. In the case of a land treatment site, the soil is likely to be a mixture of soil and waste. Factors influencing soil/waste ingestion include the type of animal, the type of soil and type of forage, stock density and other management variables, rainfall, and earthworm populations (6,7).

Grazing animals have been estimated to ingest soil in amounts ranging from 2 to 14 percent of the diet (8). Healy has shown that soil can make up as much as 8 percent of the dry matter intake of

13

grazing cattle (9). Furthermore, cattle have been observed grazing on land used for the application of industrial sludges (10).

In 1976, in Bloomington, Indiana, municipal sludge laden with PCBs was applied to pasture land which was grazed by a single dairy cow. The PCB levels of the sludge ranged from 240 to 1,700 ppm and soil levels in the pasture reached 200 ppm PCBs (11). As a result of grazing in this pasture, the cow's milk contained 5 ppm PCBs (fat basis), and was thus not fit for human consumption. (The FDA tolerance for unavoidable PCBs in milk shipped interstate commerce is 1.5 ppm.)

Other instances of the transfer of toxic organic compounds from pasture soil to grazing animals have been reported. In Gossimer, Louisiana, hexachlorobenzene was accidentally spilled onto pasture land, resulting in the impoundment of 20,000 cattle, until levels of the contaminant in these animals were reduced (12). In Maryland, heptachlor used for the control of weevils in alfalfa was later found to have contaminated the milk of grazing animals (13). Harrison et al., have shown that soil containing DDT residues can supply considerable amounts of total DDT to ewes and that these residues can be transferred to lambs (14).

Some organic wastes may vaporize and redeposit on the tissue of plants. While few studies have been done in this area, information has been developed which shows that lipophilic (oil) crops like soybeans tend to take up lipophilic hydrocarbons like chlorinated hydrocarbon insecticides. Also, the surface of the leafy plants can become contaminated with small amounts of these materials, resulting primarily from their vaporization from the

soil and redeposit on the plants. The risks of the contamination in this instance is under study (15).

The adherence of toxic substances to crops is another avenue for transfer. The likelihood of surface contamination occurring is greatest when liquid waste are applied directly to growing crops, or when the edible portion of the plant is in direct contact with treated soil. An example of surface contamination by the second means is a case where DDT was once applied routinely to sweet corn in large amounts to control the corn ear worm. It has since appeared on the surface of carrots grown in the same fields, and has made those carrots unsuitable for sale (12).

Nearly all of the published work on adherence of land-applied wastes to growing crops is based on application of municipal sludge. However, Batey, et al., found high levels of copper and zinc in or on crops sprayed with swine manure slurries (16). Boswell found high levels of cadmium, lead, and chromium on foliage following application of municipal sludge filter cake (16). Chaney and Lloyd have shown that municipal sludge applied to pasture grass can, shortly after application, result in the adhered sludge making up 30 percent of the dry weight of the crop (17). Rainfall and weathering over an 80-day period did not remove much of the sludge from the grass. However, the 80 days of growth permitted a dilution of the weight of the sludge to the weight of the crop. Still, at the end of the 80-day period, 5 percent of the dry weight of the grass was actually found to be adhered sludge. This study was performed in the rainy east, and therefore, one would expect that sludge application to grasses in more arid regions would result in

20

even greater adherence of the sludge to the crops. A greenhouse study by Jones et al., using simulated rainfall, resulted in similar conclusions to those of Chaney and Lloyd (18). Once the sludge had dried on the grass, rainfall was not effective in reducing the amount of adhered sludge. Rainfall was found only to be effective if it occurred immediately after sludge was applied.

Heavy metals, such as cadmium, molybdenum, selenium, mercury, and lead, can be absorbed by crops from the soil of land treatment facilities. The uptake of mercury and lead by most crops, however, is not nearly of the magnitude of these other metals.

Cadmium may be taken up by plants even though only very low levels exist in the soil. The transfer of cadmium from the soil to plants is well documented in the background document supporting EPA's recently promulgated Criteria for Classification of Solid Waste Disposal Facilities and Practices. Crops such as leafy vegetables or root crops take up significantly greater amounts of cadmium than do grains or grasses.

Maintaining a near-neutral pH on a land treatment facility to control plant uptake of most heavy metals can lead to an increase in the uptake of molybdenum and selenium. These two metals are more soluble at neutral and basic pH's. Molybdenum's toxicity has been a serious problem in livestock food production in certain areas of the western United States. Forages grown on naturally wet, alkaline, or neutral soils can contain toxic concentrations of molybdenum (19). Certainly, the land application of wastes high in molybdenum to such soils would aggravate this naturally-occurring problem.

(21)

In Oregon, a study using shredded municipal waste at an application rate of 900 metric tons per hectare resulted in a significant uptake of molybdenum by alfalfa. The levels reached would have been potentially hazardous to livestock if only one feed source was used (20).

Land treated wastes do not generally increase levels of mercury in plants. However, Van Loon found very considerable levels of mercury in tomatoes where municipal sludges (the highest containing 25 ppm mercury) were used (18,21). Results of Yugoslav studies showed that mercury levels of most plants were low (1 to 50 ppb) compared to the mercury content of soils in which they grew (100 to 600 ppm). Carrots, grasses, and some weeds had more mercury (800 ppb) than other plants. Jackson found that mercury in the tops of barley and soybean plants whose roots were in a mercury solution came from mercury vapor released from the roots, rather than from translocation. If mercury volatilizes from waste-treated soils, plants could absorb it (22).

Significant increases in the lead content of some crops as a result of soil application of lead have been reported, particularly in soils deficient in phosphate (23). Because of the buffering capabilities of soils and plant roots, as well as absorption and precipitation phenomena, most lead in soils is not likely to be translocated to the above-ground portions of plants. However, uptake to the above-ground portions can be appreciable following changes in the environmental and physiological condition of the plant (24). In fact, investigations of existing land treatment sites have indicated that significant increases can occur in the

22

In Oregon, a study using shredded municipal waste at an application rate of 900 metric tons per hectare resulted in a significant uptake of molybdenum by alfalfa. The levels reached would have been potentially hazardous to livestock if only one feed source was used (20).

Land treated wastes do not generally increase levels of mercury in plants. However, Van Loon found very considerable levels of mercury in tomatoes where municipal sludges (the highest containing 25 ppm mercury) were used (18,21). Results of Yugoslav studies showed that mercury levels of most plants were low (1 to 50 ppb) compared to the mercury content of soils in which they grew (100 to 600 ppm). Carrots, grasses, and some weeds had more mercury (800 ppb) than other plants. Jackson found that mercury in the tops of barley and soybean plants whose roots were in a mercury solution came from mercury vapor released from the roots, rather than from translocation. If mercury volatilizes from waste-treated soils, plants could absorb it (22).

Significant increases in the lead content of some crops as a result of soil application of lead have been reported, particularly in soils deficient in phosphate (23). Because of the buffering capabilities of soils and plant roots, as well as absorption and precipitation phenomena, most lead in soils is not likely to be translocated to the above-ground portions of plants. However, uptake to the above-ground portions can be appreciable following changes in the environmental and physiological condition of the plant (24). In fact, investigations of existing land treatment sites have indicated that significant increases can occur in the

22

lead content of crops, such as clover and various grasses (22).

In general, a minimal amount of toxic organic compounds are absorbed by plant roots and transferred to other parts of the plant. Organics with large molecules, such as pesticides and PCBs, do not tend to pass the semipermeable membrane of plant roots. Consequently, plants possess the ability to exclude large organic molecules added to soils, which result in minimal impact on the quality of forage and grains (21). An exception is organochlorine pesticides which are absorbed by plant roots and transferred to other parts of the plant, but at a very low rate compared to the concentration in the soil (24).

The absorption of PCBs by plant roots and translocation within plants is considered minimal, but some studies have reported what appeared to be low levels of plant uptake as a result of heavy application rates (25). These studies further suggest, however, that PCBs are not actually taken up by the plant but, rather, are physically adsorbed on the surface of the roots (21).

The examples do suggest that there are known cases where translocation of toxic substances to crops has occurred, and that there is a significant potential for contamination of crops from soils treated with hazardous wastes to crops grown on that soil.

The Agency also examined the benefits to be gained from growing food-chain crops in treated soils. The Agency believes that such benefits are minimal. Certainly the very small amount of land so used is not needed for food growth from a national perspective. It represents a negligible portion of the total productive land for crops needed for food growth from a national perspective. It

represents a negligible portion of the total productive land for crop growth available in this country. Furthermore, there are other productive uses of such land, for example, crop farming of non-foodchain crops, if crop growth is desired. The Agency recognizes that growth of food-chain crops can result in a source of revenues to help defray disposal costs. However, the Agency does not believe that such revenues minus the cost of growing and marketing the crops, especially in light of the cost of waste and crop monitoring and other controls needed to ensure protection of public health, are significant to the economic viability of land treatment.

The Agency considered the alternative of specifying safe application rates of various wastes to the soil for growth of food crops. The Agency also considered establishing safe levels of various substances in plants and requiring crop monitoring to control potential hazards. As the above discussion points out, the data and information base available for such an approach does not exist.

In view of all of the above considerations, the Agency concluded that it should ban the growth of food-chain crops on hazardous waste land treatment facilities.

B. Summary of Comments

- ° The term "food-chain crops" means tobacco; crops grown for human consumption; or crops grown for pasture, forage, or feed grain for animals whose products are consumed by humans.
- ° The regulation is too restrictive. If studies of plant tissue residues and crop uptake demonstrate that the crop will not take up the hazardous constituents, growth should be permitted.

- ° The restriction will abolish the practice of growing food chain crops at land treatment facilities. EPA should require tests to determine if crops grown on such land are suitable for consumption by humans or livestock
- ° Growth of food-chain crops should be permitted if, after study over two growing seasons, the consumable part of the crop can be shown to be non-toxic.
- ° The regulation is too restrictive. It should be replaced with a requirement for monitoring of crop uptake of hazardous constituents.
- ° The regulation is too restrictive. The regulations should take into consideration the hazardous characteristics of the waste, the nature of the soil, and the substance being taken up by crops. Growth should be allowed.
- ° The regulation should be based on application rates of waste, rather than a prohibition. EPA should develop regulations controlling application and specifying testing requirements.
- ° The issue is blown out of proportion. Many hazardous wastes are phytotoxic, which makes growth of any crop impossible. However, other wastes are amenable to land treatment on crop land.
- ° Growth of food-chain crops should not be prohibited without qualification. Certain crops and grasses have assimilative capacity for a variety of potential hazardous waste, e.g., bermuda grasses. Without their use, land treatment facilities would have to be bigger.
- ° The prohibition is inconsistent with EPA's position on POTW sludge. Textile sludges present no greater toxic potential than POTW sludges.
- ° Studies have shown that land treatment of utility ash and sludge do not result in unsafe levels of potentially hazardous contaminants in crops. Gypsum and fly ash are used routinely to correct soil deficiencies. An exception should be provided where reasonable evidence and studies show that there is no substantial hazard to human health.
- ° The regulation would prohibit using waste lime as a soil conditioner on crop lands. Waste limes from the sugar beet refining process or from lime kilns have high levels of CaCO_3 (85 percent) and MgCO_3 (5 percent), which neutralize acid soils. Waste lime from beet processing has been in use for 25 years.

- ° Crude oil does not have as high a concentration of heavy metals as other waste oils. It has been demonstrated that waste crude oil adds nutrient value and that it is perfectly safe to grow crops on land so treated.
- ° The regulation would eliminate land treatment of waste for beneficial uses, i.e., as agricultural fertilizers. It would raise disposal costs by 700 percent. Thus, there is a poor risk and benefit ratio for a ban.
- ° The prohibition is totally appropriate, since there is very little information on toxics and persistent organics beyond the work on metals in POTW sludges. Until data are developed on crop uptake of these other toxins, land contaminated with them should not be used for agricultural purposes.

C. Discussion

The following discussion is based largely on the above comments. The substance of the comments are paraphrased as numbered items (1) through (9), and discussion pertinent to the paraphrased comment follows. The last numbered item is a summary discussion of basis for the requirements as the Agency as set them forth in the repropoed regulations.

- (1) Food chain crops should be defined.

A definition for "food chain crops" was provided in the proposed rules on page 58997, Section 250.41(b)(33). The same definition is included in the final interim status regulations. The definition reads: "Food chain crops" means: tobacco; crops grown for human consumption; or crops grown for pasture, forage, or feed grain for animals whose products are consumed by humans." This definition does not preclude the growing of a crop which is normally consumed by humans or animals if the crop is only grown as a ground cover and then plowed under.

(2) Monitor crop uptake.

The option of analyzing a crop for uptake of hazardous constituents is conceptually attractive, but presents certain problems in practice. The most basic problem is that crop tolerance levels have not been established for most of the hazardous constituents of concern; hence, there is no standard of comparison.

However, the Agency does believe that crop monitoring represents an acceptable general approach when comparing hazardous constituents in the crops to background levels. Comparing crops grown on land treatment facilities with crops grown in nontreated soils is the only feasible way of applying crop monitoring in most situations, due to lack of defined tolerance levels. The revised regulatory language permits an owner or operator to present such data to the Agency as a part of the support for a claim that growth of a crop on a land treatment facility presents no danger to public health.

- (3) Prescribe acceptable application rates. Base the standard on the characteristics of the waste, the soil, and the crop being grown. Many wastes are amenable to land treatment on cropland.

This approach, perhaps coupled with crop monitoring, would be an ideal approach if the state-of-the-art would support it.

Unfortunately, this is not the case. Except for cadmium, information on acceptable application rates is not available for combinations of soil, hazardous wastes, and crops. Consequently, this approach is not feasible as a general approach at this time. Such an approach is used for cadmium, however, because there is sufficient data to support it. However, the Agency believes that it is important to begin to develop this information through

monitoring of conditions in a land treatment facility. Furthermore, the Agency believes that an owner or operator should have the opportunity to demonstrate to the Agency that it has developed such information for a particular situation. This concept is also embodied in the interim status standards.

- (4) Certain crops and grasses have assimilative capacity for potentially hazardous substances, e.g., bermuda grasses. The regulation should be qualified to allow their growth.

The proposed regulation is not without qualification in that only food chain crops are restricted. Crops which are not used for human consumption or consumed by animals whose products are not consumed by humans are not restricted. Therefore, a crop such as bermuda grass can be grown at a land treatment site for the purpose of assimilating waste components or providing ground cover. In this case, the grass could not be used as an animal feed for animals whose products are consumed by humans. Because a food chain crop is defined by its end use, crops which may normally be considered food chain crops can be grown at a land treatment site if adequate measures are taken to prevent its consumption by humans or animals whose products are consumed by humans.

- (5) The prohibition is inconsistent with Subtitle D regulations. Textile sludges present no greater hazard to crop growth than wastewater treatment sludge.

The Agency agrees that the approaches are currently different. However, the cadmium standards established in the Criteria have been incorporated into the interim status standards in order to have consistency between those two regulations. The requirements concerning PCB in the Criteria were not included at this time. This issue will be resolved as part of the consideration between

25

the RCRA programs and the Agency program for handling PCB under the Toxic Substance Control Act. Also, the interim status standards will provide an owner or operator the opportunity to present data showing that crop growth on such waste is safe.

- (6) Utility ash and sludge is beneficial to some solids; presents no hazard to crops.

The interim status standards will allow an owner or operator to grow food chain crops at a land treatment facility, provided there is data indicating that such a practice does not pose a threat to public health. Therefore, the owner or operator of a land treatment facility receiving utility ash and/or sludge may grow food chain crops provided he can document that such crops are safe.

- (7) The regulation would prohibit using waste lime as a soil conditioner on crop lands.

The Agency acknowledges the point raised by this comment and has exempted waste lime from this prohibition if it is only classified as a hazardous waste due to its high pH. This provision is specified in Part 261.

- (8) Crude oil adds nutrient value to the soil, and crop growth on land so treated is safe.

As with all waste which is classified hazardous, the interim status standards will allow an owner or operator to grow food chain crops at a land treatment facility provided there is data indicating that such a practice does not pose a threat to public health.

- (9) The prohibition would eliminate land application of hazardous waste for use as agricultural fertilizers and raise disposal costs by 700 percent.

No data to support the claim of a 700 percent cost increase

(28)

were provided, and the Agency disagrees strongly with this estimate. Since the prohibition only applies to the growing of crops for human consumption or for consumption by animals whose products are consumed by humans, the Agency does not believe that this restriction will result in a major impact on the land treatment of hazardous wastes. Because food chain crops often have a higher market value than non-food-chain crops, there may be some reduction of income from land treatment sites. However, because many non-food-chain crops are often grown on less productive lands, the agricultural fertilizer value of the hazardous wastes may be better utilized by these crops. Thus, the Agency sees no clear or significant benefit from growing food chain crops.

(10) Summary discussion.

The Agency proposed a ban on the growth of food-chain crops at hazardous waste land treatment facilities. After reviewing comments, EPA decided that during the interim status period, food-chain crops may be grown, provided that certain requirements are met. The Agency's decision not to continue with the ban during the interim status period is based on the following reasons: First, there exist insufficient data to indicate that the growth of food-chain crops at a hazardous waste land treatment facility would always create a risk to those who consume such crops. Second, banning the growth of food-chain crops would be inconsistent with the regulatory approach taken to protect food-chain crops under Subtitle D of RCRA. These regulations were finalized as the Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR 257) on 13 September 1979.

The Agency believes it would be unjustified to impose a ban on the growth of food-chain crops at land treatment facilities if there were convincing evidence that the crops can be grown without posing a significant public health risk. It is conceivable that a substance in a hazardous waste may not be taken up by certain food-chain crops, or after a period of treatment, the substance may degrade into products non-hazardous to humans.

For example, some wastes may be used to control pH of the soil, and there may be a significant body of data which supports that such a use does not pose a public health risk. The Agency does not wish to prohibit such uses of waste, realizing that the waste may simply be replaced with commercial product containing the same chemical constituents as the waste.

The cadmium standards detailed in the Criteria do not set limits for food-chain crops, but instead prescribe annual application rates and limits on cumulative loading based on the specific health risk posed by cadmium. As a result, a waste, regardless of the cadmium concentration, may be applied to land on which food-chain crops are grown. Compliance with the Criteria can be achieved merely by applying less waste. The Agency believes it would be unjustified in banning the growth of food-chain crops at facilities receiving waste that is hazardous due to cadmium, since such a waste can be applied in a manner that would not violate the standards prescribed in the Criteria.

The Agency, while not considering a ban appropriate because of the reasons mentioned, had to deal with the task of how to structure the regulations to permit the growth of food-chain crops, and at

(31)

the same time be assured that public health would be protected. In order to achieve this, the Agency devised a two-part test to determine whether food-chain crop growth on land treatment facilities is acceptable. The two-part test requires the owner or operator, prior to growing a crop, to demonstrate that the hazardous waste constituents in the waste, as well as arsenic, lead and mercury will not (a) be transferred to the edible portion of the crop by plant uptake, by direct contact or by transfer to food-chain animals; or (b) occur in greater concentrations in the crop than in crops grown on control soils under similar circumstances in the region.

In order to demonstrate comparability, an owner or operator must use actual field studies. A test plot would be considered an acceptable field study. Also, the conditions under which the comparable crops are grown must be similar to the conditions found at the facility. For example, soil type, soil moisture, soil pH, soil nutrients, photo period and length of growing season, must be similar at both facility and control sites. The owner or operator must also document the sample selection criteria, sample size determination, analytical methods and statistical procedures used to make the demonstration. In order to establish compliance prior to waste application, the owner or operator must pre-test samples of the crop using the type of waste and application rate that will be used at the facility. The sample must be that portion of a crop which would be consumed (e.g., corn kernel, wheat grain etc).

The two-part test approach is based on the premises that since the Agency does not have a clear specification of the "no risk"

level of such contaminants in food crops, it is reasonable to assume that the level of such contaminants presently in food crops is acceptable. However, future research data may indicate that health tolerances in food crops should be higher or lower than the average levels otherwise present in such crops.

Arsenic, lead, and mercury were specifically identified because of their relatively high toxicity to humans and evidence that they can be taken up by crops (26). Mercury can enter plants through the roots and be readily translocated throughout the plant. Arsenic tends to accumulate in the roots of most crops, which is a concern when root crops such as radishes, carrots, etc., are grown. When in high concentrations in the soil, lead has been shown to translocate to crops.

The Agency is concerned that there are other hazardous substances in the wastes, e.g., toxic organics, that may be taken up by crops. The difficulty in identifying toxic organics is due to the lack of data in this area. Most crop studies have addressed only inorganics or pesticides; thus there is a paucity of data on the uptake of many other toxic organics by crops. However, the Agency will identify other hazardous substances of concern as information becomes available.

In order to be consistent with the Criteria for the Classification of Solid Waste Disposal Facilities and Practices, the standard developed in those regulations for cadmium has been incorporated into the interim status regulation. Thus the cadmium standard present in the Criteria will be applicable to hazardous waste land treatment facilities.

23

The Criteria include two approaches for the land application of wastes containing cadmium. The first approach incorporates four site management controls; control of the pH of the waste and soil mixture; annual cadmium application limits that are reduced over time; cumulative cadmium application limits based on soil cation exchange capacity (CEC); and restriction of the cadmium concentration in waste applied to facilities where tobacco, leafy vegetables and root crops are grown.

The second approach allows unlimited application of cadmium provided that four specific control measures are taken: first, the crop grown can only be used as animal feed. Second, the pH of the soil must be maintained at 6.5 or above for as long as food-chain crops are grown. Third, a facility operating plan must describe how the animal feed will be distributed to prevent human ingestion: Fourth, future owners are provided notice (through provisions in land records of property deed) that there are high levels of cadmium in the soil and that food-chain crops should not be grown.

The Agency believes that the Interim Status Standards adequately protect public health, and therefore has adopted a similar approach for the proposed regulations under this section. However, one section of the Interim Status Standards has been modified for the purpose of this section. The modification is the deletion of the "phasing" approach for the annual application of cadmium. Under this approach the annual application of cadmium is reduced over a set period of time. The time schedule starts from the present to June 30, 1984 and allows 2.0 kg/ha of cadmium to be applied. From July 1, 1984 to December 31, 1986 the amount is reduced to 1.25

(34)

kg/ha, and further reduced to 0.5 beginning January 1, 1987.

The cadmium limits promulgated under Subtitle D of RCRA are primarily aimed at controlling wastewater treatment sludges containing high levels of cadmium from being placed on agricultural lands. The phased time period for the reduction of cadmium applied to agricultural lands is used in order to correspond with the pretreatment schedule that wastewater treatment facilities (POTW's) must meet, in accordance with the Clean Water Act, to reduce the amount of cadmium in their sludges. The Agency believes that by using the same schedules, implementation of the regulation can be carried out without causing an undue hardship on operators of wastewater treatment facilities, and at the same time be assured that public health will be protected.

Because the phased schedule for controlling the annual application of cadmium is oriented primarily towards wastewater treatment sludges, the Agency has decided not to incorporate it into regulations under this Section. Instead, the 1987 annual cadmium application rate of 0.5 kg/ha is used. The Agency feels that it is more appropriate to use the 1987 cadmium limits since most wastewater treatment sludges probably will not be classified as hazardous wastes, and to apply the phased time period to waste other than wastewater treatment sludge would be contrary to its original purpose. However, in the future, the phased schedule for annual cadmium application rate may be incorporated into the regulations under this Section if the Agency finds that large quantities of wastewater treatment sludge are falling within the hazardous category. Also, it should be noted that the Agency is

currently developing regulations under Section 405 of the Clean Water Act that will address cadmium limits applied to food-chain crop lands. These regulations, when promulgated, may make it necessary for the Agency to modify existing cadmium limits in order to have consistency in its approach to control the application of cadmium to food-chain crop lands.

D. Regulatory Language

(a) Owners or operators of land treatment facilities who propose to grow food chain crops after the effective date of this Part must comply with paragraphs (b) and (c) of this section.

(b)(1) Food chain crops must not be grown on the treated area of a hazardous waste land treatment facility unless the owner or operator can demonstrate, based on field testing, that arsenic, lead, mercury, or other constituents:

(i) Will not be transferred to the food portion of the crop by plant uptake or direct contact, and will not otherwise be ingested by food chain animals (e.g., by grazing); or

(ii) Will not occur in greater concentrations in the crops grown on the land treatment facility than in the same crops grown on untreated soils under similar conditions in the same region.

(2) The information necessary to make the demonstration required by paragraph (a)(1) of this section must be kept at the facility and must, at a minimum:

(i) Be based on tests for the specific waste and application rates being used at the facility; and

(ii) Include descriptions of crop and soil characteristics, sample selection criteria, sample size determination, analytical

30

methods, and statistical procedures.

(c) Food chain crops must not be grown on a land treatment facility receiving waste that contains cadmium unless all requirements of paragraph (c)(1)(i) through (iv) of this section or all requirements of paragraph (c)(2)(i) through (iv) of this section are met.

(1)(i) The pH of the waste and soil mixture is 6.5 or greater at the time of each waste application, except for waste containing cadmium at concentrations of 2 mg/kg (dry weight) or less;

(ii) The annual application of cadmium from waste and soil cadmium does not exceed 0.5 kilograms per hectare (kg/ha).

(iii) The cumulative application of cadmium from waste and soil cadmium does not exceed 5 kg/ha if the waste and soil mixture has a pH of 6.5.

(iv) If the waste and soil mixture has a pH of 6.5 or greater, or is maintained at a pH of 6.5 or greater during crop growth, the cumulative application of cadmium from waste and soil cadmium does not exceed: 5 kg/ha if soil cation exchange capacity (CEC) is less than 5; 10 kg/ha if CEC is 5-15; and 20 kg/ha if soil CEC is greater than 15.

(2)(i) The only food chain crop produced is animal feed.

(ii) The pH of the waste and soil mixture is 6.5 or greater at the time of waste application or at the time the crop is planted, whichever occurs later, and this pH level is maintained whenever food chain crops are grown.

(iii) There is a facility operating plan which demonstrates how the animal feed will be distributed to preclude ingestion by humans.

6

The facility operating plan describes the measures to be taken to safeguard against possible health hazards from cadmium entering the food chain, which may result from alternative land uses.

(iv) Future property owners are notified by a stipulation in the land record or property deed which states that the property has received waste at high cadmium application rates and that food chain crops should not be grown, due to a possible health hazard.

5. Unsaturated zone (zone of aeration) monitoring - \$264.278

ISSUE: Soil and soil-pore water monitoring

A. Proposed Regulations and Rationale

The proposed soil monitoring requirements included:

- ° Determine background soil conditions by taking one soil core per acre in the area to be treated at a depth of three times the depth of the zone of incorporation, or 30 centimeters, whichever is greater. The bottom one-third of the soil core must be analyzed for the hazardous constituents in the waste.

At new facilities, the cores must be taken prior to beginning operation. At existing facilities, the cores must be taken within six months of the effective date of the regulations.

- ° Soil conditions in the treated area of a land treatment site must be determined by taking one soil core per acre semiannually at three times the depth of the zone of incorporation, or 30 centimeters, which is greater. The bottom one-third of the core must be analyzed for the hazardous constituents in the waste.
- ° If soil monitoring shows that the concentration of a hazardous constituents significantly exceeds background levels, the owner/operator must: (1) notify the Regional Administrator within seven days, (2) determine the areal extent of vertical contaminant migration, and (3) discontinue all land treatment in the contaminated area until corrective measures are taken.

There were three basic elements to this proposed procedure, each with a separate rationale. These elements were the sampling procedure (i.e., number of samples), the depth of the core samples,

and the corrective action required. The sampling procedure was based largely on subjective reasoning of how many samples would be required to obtain an adequate representation of the soil in the landfarm. The requirement was not based on a statistical test.

The corrective actions specified were based on the assumption that migration of contaminants to a depth of three times the depth of the zone of incorporation constituted a potential threat to public health and the environment, and that no further land treatment should occur until this situation was corrected, as determined by the Regional Administrator.

Perhaps the most significant element of the requirement was the selected depth of three times the depth of the zone of incorporation as the "performance standard" for the facility. This standard was based on a number of technical studies which suggested that in a properly designed and operated land treatment facility, there should be little or no migration of contaminants beyond the zone of incorporation.

The Agency has identified a considerable amount of literature and empirical data indicating limited waste migration at hazardous waste land treatment facilities.

A literature review by Page (27) in 1974, evaluated the potential hazards of the application over 10 years of sewage treatment plant wastes to agricultural soils. Page found that in most soils, the percentage of heavy metals (Ag, Ba, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Zn), applied in the form of sludge which move beyond the depth of tillage, is quite small. This same phenomenon has been observed in field studies where oily hazardous

waste has been land treated. Meyers and Huddleston (28) applied oil refinery waste (API Separator Sludge, tank bottoms, slop oil) at three different application rates over a period of three years. The study indicated no significant leaching or migration of organic or inorganic waste constituents. Similar findings were reported by Kincannon (2) in his review of an 18-month field study conducted in 1971. Three types of oil feed materials were selected to represent different combinations of hydrocarbon types. The oil types included oil tank bottoms, bunker C fuel oil, and waxy oil. Neither oil nor nutrients (added as fertilizer) migrated vertically during the study.

A state-of-the-art study (3) on land treatment of municipal and industrial wastes found no incidents of water pollution at any of the six sites studied. Soil sampling at these sites suggested that heavy metals and trace elements appear to be retained in the zone of incorporation.

B. Summary of Comments

(1) Soil monitoring vs. ground-water monitoring

- ° Neches' land treatment research supports EPA's conclusions that soil monitoring will detect any migration long before ground-water monitoring could detect it.
- ° Ground-water monitoring at land treatment facilities is unnecessary, especially with the proposed siting and surface controls outlined in §250.45-5(b) and (c).
- ° Because our own data has shown little migration, we strongly support soil monitoring in lieu of ground-water monitoring. If, at some later time, soil monitoring indicates significant migration, ground-water monitoring could be commenced.
- ° Because the published literature clearly shows little migration, we strongly support soil monitoring lieu of ground-water monitoring.

- ° The proposed soil monitoring program is not adequate to protect ground water resources. Some potential ground-water contaminants migrate slowly through soils; however, there are many potential contaminants that can migrate very quickly through soils, depending on soil conditions and waste characteristics. Situations could exist where potential ground-water contaminants would migrate to ground water and not be detected by semiannual soil monitoring.
- ° EPA could not identify a single incident of ground-water contamination resulting from land treatment of hazardous wastes, which would indicate that the soil monitoring requirements are overly restrictive and should be replaced by test wells at the property line. Soil monitoring should be performed, but for day-to-day operations, not for compliance monitoring.

(2) Soil monitoring

(a) Sampling procedure (number of samples; extent of analysis)

- ° Analyzing for all hazardous components is unreasonable and expensive. Should analyze only "as necessary" to detect vertical migration of wastes. It is beyond present day knowledge to analyze for all hazardous constituents since:
 - many wastes are very complex and variable in composition
 - quantitative analysis may not show biological activity or the chemical form of some components.
 - very few labs have the expertise or equipment to do quantitative analysis of soil samples, and there are few standardized analysis procedures

Because of the above, one should analyze for indicators or tracers, such as bromide.

- ° Should analyze for degradation products rather than wastes, as applied. Should change the regulation to "analysis as necessary to detect vertical migration of hazardous constituents."
- ° Accumulation of waste constituents in the soil should be compared with "acceptable" levels of those constituents rather than with background.
- ° The number of samples and extent of analysis is excessive for low hazard wastes, and would be expensive (\$200-\$400 per sample). Should analyze only for major species unless migration is detected. For example, large treatment areas with uniform terrain and cover crop would hardly require so many samples and would result in redundant data.

(41)

Analyzing for all constituents which make the waste hazardous is overkill, also. (Comment listed 28 substances which potentially would have to be monitored for fly ash and scrubber sludge.) Should analyze for major species initially, such as Ca, Na, SO₄, etc. If migration is indicated, then more extensive trace analysis could be done.

- ° No methods were provided for obtaining core samples, and there is an absence of analysis methods and methodology for determining background condition. Should require a minimum of 10 background samples and not less than one per acre.
- ° Soil monitoring and comparison to background analyses is too vaguely described. Suggest that a periodic report of analyses be required and that the definition of "significantly exceeded background levels" be more scientifically specified.
- ° Should define significant increase over background. Suggest defining significant increase in terms of number of samples, i.e.:

<u>No. of Samples</u>	<u>Significant Increase over Background</u>
1	1.2
2	1.4
3	1.6
4	1.8

- ° One sample per acre is arbitrary and unreasonable. Soil samples are time-consuming and expensive, and should be minimized. Five samples are sufficient--one on each corner and one in the center of the facility, for plots of 50 acres or less.
- ° For background purposes, one core per acre is excessive and expensive. Should sample the four corners and middle of the treated area. If these samples show inconsistencies, then additional samples could be taken.
- ° The cost of sampling large land treatment areas will be exorbitant and for no good reason. Uniformity of the soils in the tract can be determined by sampling of the four corners and middle of the site.
- ° Should allow a variance for the owner or operator to show that his sample will give representative results.
- ° Far fewer than one soil core per acre would accomplish adequate testing at three times the depth of the zone of incorporation. Testing of each acre, if necessary, should be confined to the actual zone of incorporation.

- ° Background and treated soil conditions can be determined without requiring one core per acre. A more rational and reasonable requirement would be one soil core per 10 acres, but not less than one core per treated area.
 - ° The total number of soil core samples to be analyzed annually is excessive and should be reduced by either taking fewer samples per total acreage as acreage increases, or lengthening the sampling frequency from semiannual to annual. Suggest the following to give adequate quantities of soil core samples to be analyzed:
 - one core per acre for 5 acres or less
 - one core per 1.5 acres for 6 to 9 acres
 - one core per 2 acres for 10 to 30 acres
 - one core per 4 acres for greater than 60 acres
 - ° One soil core per acre represents considerable redundancy. Samples should be taken to represent specific areas receiving specific wastes at particular application rates. An area receiving a specific waste mix at a uniform application rate throughout the area should be treated as a single unit for soil sampling and analysis.
 - ° Testing of a subsample of composited samples from several different locations in an area receiving a particular waste at a particular application rate should be allowed.
- (b) Depth of sampling (three times the depth of the zone of incorporation)
- ° Limiting migration to three times the depth of the zone of incorporation is arbitrary and unreasonable. Application to the surface should not be more limited in penetration limits than deeper application. Migration limits should be based on case-by-case conditions and should allow the owner/operator to demonstrate that no ground water threat exists.
 - ° Limiting migration to three times the depth of the zone of incorporation is not acceptable. Should allow migration to a depth safely above the shallowest usable ground water. Some land treatment facilities may be underlain by a hundred feet of non-water-bearing soil capable of absorbing contaminants.
 - ° Application of wastes with high solids content will raise the surface of the land treatment facility gradually, eventually causing problems with the definition of the zone of incorporation. Suggest that core depths be

determined from the initial depth and location of the zone of incorporation.

- ° A fixed core depth, such as three feet, should be established from the initial level of the zone of incorporation. The reason is to take advantage of the assimilative capacity of the soil to arrest transport of contaminants, yet provide a reasonable depth for monitoring to assure that the transport is not excessive. These requirements have nothing to do with the depth to which the soil was plowed, so should not be tied to that depth. This overcomes the problem of defining a (sample) depth when waste is not plowed at all.
- ° Surface soils should be sampled as protection for the land treatment facility operator, since soil composition can change dramatically with depth and composition of surface soils are subject to change due to various manmade activities and emissions.
- ° The soil monitoring requirements should be broadened to include anaerobic operations. Aerobic and anaerobic operations do not occur in the same locations in the soil profile and final monitoring should not be done until after the last operation in the sequence. An example is denitrification. A high nitrogen waste would yield nitrate in the aerobic zone within 12 inches of the zone of incorporation. Further down, the nitrate will denitrify (convert to nitrogen gas) under proper conditions. Soil monitoring locations do not relate to the zone of incorporation in this case.
- ° The limitation on significant increase of hazardous contaminants below the zone of incorporation is in conflict with the planned dilution of certain inorganic ions in the ground water, i.e., chloride. A waste may be hazardous because of its concentrations of chloride or sulfate. It is well recognized that the chloride does not degrade and will eventually dilute in the ground water. This should be recognized in the regulations.
- ° We agree with the depth of three times the depth of the zone of incorporation, or 30 centimeters, whichever is greater, for taking soil samples.

(c) Corrective action

- ° Requiring land treatment facilities to cease operations and perform corrective actions upon detecting an increase above background may force land treatment facilities to close when no threat to underground drinking water supplies or human health exists. Instead of requiring that operations be discontinued, EPA should require that the magnitude of the threat to area ground water be determined and that,

based on this analysis, the Regional Administrator may order the land treatment facility to be closed and/or corrective action taken. Requiring the owner/operator to cease operations and take corrective action is justified if human health and the environment are endangered. However, a significant increase over background does not necessarily constitute a threat. Soil monitoring should be used to indicate when further investigation is warranted to determine if corrective action is necessary.

- ° This comparison with background and corrective action restricts the mechanism by which land treatment functions. Concentrations of constituents added to a landfarm will certainly increase in the zone of incorporation and, to lesser extent, at the depths cited. Otherwise, such constituents would have had to be discharged either to ground or surface waters. The fact that background levels have been exceeded in no way demonstrates that the soil's capacity for assimilation has been reached. The regulation should establish "safe levels" at which constituents can be applied and assimilated.
- ° The requirement that operations be discontinued until the Regional Administrator determines what actions are to be taken is unnecessarily strict and violates due process. It is too stringent because it ignores the possibility of analytical error, the importance of the finding in the particular circumstance, and the consequences of the closedown decision. It should be sufficient to require immediate notice to the Administrator and, perhaps, the requirement to conduct more frequent sampling and analysis. The Regional Administrator always has recourse to the imminent danger provisions of RCRA Section 7003. The proposal violates due process rights of the owner/operator, as no standards are established for RA determinations, nor is the RA required to make his determination within a particular time. Thus, the RA has absolute discretion, both as to when he will make a decision and what the decision will be.
- ° Merely detecting contaminants below the zone of incorporation does not constitute a threat to ground water. The regulations seem to assume that any migration of contaminants poses a hazard to ground water. This assumption is not true. Soil monitoring is a useful tool that should not be relied upon totally to provide ground water protection.
- ° In the event that a significant increase of hazardous constituents appears below the tilled depth, what is the recommended correction procedure? Complete removal and landfilling of the fill? Is it presumed that this senseless approval of land spreading of hazardous waste is an attempt to justify the advocacy of extensive and almost uncontrolled sewage sludge farming?

C. Discussion

(1) Soil monitoring vs. ground-water monitoring.

Comments received on this issue clearly favored some form of soil monitoring over ground-water monitoring, however, several commenters felt that ground-water monitoring was also necessary. These commenters contended that soil monitoring had certain limitations (e.g., low reliability of detecting highly mobile contaminants), "and should not be solely relied upon to provide protection of our ground-water resources." The Agency recognizes that rapidly migrating contaminants could be missed by soil monitoring. Recently, researchers at Texas A&M have discovered that organic compounds migrated through field tests plots at a rate that was three times faster than water (29). The waste applied to the test plots was API separator sludge. This waste is commonly land treated at many oil refineries.

Additional impetus for ground-water monitoring came indirectly from the commenters who were dissatisfied with the Agency's interpretation of what constituted contamination. The regulations required remedial measures if contaminants migrated to three times the depth of the zone of incorporation. This facet of soil monitoring, which will be discussed in detail later, was considered to be arbitrary and precluded using the full capacity of the soil to attenuate waste. Ground-water monitoring, as required for landfills and surface impoundments, would provide a more consistent and clear determination of environmental impact at land treatment facilities.

Given the concern over the limitations of soil monitoring and

(45)

the claim that the Agency's interpretation of contamination is arbitrary, ground-water monitoring is now required at land treatment facilities during interim status. The requirements are the same as for surface impoundments or landfills.

The Agency has three reasons, in addition to those raised in the comments, for requiring ground-water monitoring at land treatment facilities. First, many of the land treatment facilities covered in existence today have not operated under the philosophy of "limited waste migration." Contaminants at these sites are likely to have already migrated beyond three times the depth of the zone of incorporation. Soil monitoring, as proposed, would provide no information on the depth, concentration, or type of contaminants that have migrated beyond the depth to which soil cores are taken. Second, at existing facilities new unsaturated zone monitoring (both soil and soil-pore water monitoring) is not reliable in indicating if contaminants have already migrated to ground water and what impact they may have on ground water. The only sure way to know at existing facilities is to monitor ground water. Third, ground-water monitoring will be used to confirm predictions made on the fate of leachate leaving the zone of incorporation from both new and existing facilities. This is an integral part of the Part 264 approach to rigorously protect ground-water resources.

(2) Soil monitoring

Responses to the comments on the proposed soil monitoring regulations are discussed collectively to facilitate presentation of the revised monitoring scheme for land treatment facilities.

One of the most prevalent points made by commenters was that

the sampling frequency should be other than one core per acre. Most of the commenters felt that the one soil core per acre requirement was excessive and the cost exorbitant. Several alternative sampling schemes were suggested, including:

- ° The number of soil cores should be variable until more research can be performed.
- ° A minimum of 10 cores and not less than one core per acre should be required, regardless of site size.
- ° An incentive to take more than one core per acre could be provided by making what constitutes a significant increase, a function of sample size, i.e., if one core per acre is taken, then an increase in the level of a contaminant of 1.2 times background would be considered a significant increase: if two cores per acre were taken, then a significant increase would be 1.4 times background, etc.
- ° For landfarms of 50 acres or less, take one core near each corner of the site and one from the center.
- ° Take one soil core per 10 acres, but not less than one soil core per treated area.
- ° The number of soil cores taken per acre should be a function of landfarm size, e.g.,:

<u>Landfarm Size (in acres)</u>	<u>Core Per Unit Area</u>
5	1 core/acre
6-9	1 core/1.5 acres
10-30	1 core/2 acres
31-60	1 core/3 acres
>60	1 core/4 acres

- ° Allow compositing of samples taken at one core per acre in areas where only one type of waste or waste mix is applied at a uniform rate.

Each of the above proposed sampling schemes, as well as the approach proposed in the regulations, is deficient in not being linked to a test of statistical significance for comparison with background levels. The Agency felt that the soil monitoring scheme had to have a statistical basis since it was a regulatory tool used

46

in determining if enforcement action would be taken at a facility. Because of the Agency's decision to require ground-water monitoring at land treatment facilities, soil monitoring will not play an enforcement role. Soil monitoring will still be required, however, it will be structured differently and will be used to substantiate predictions made about the movement of leachate in the unsaturated zone.

Commenters suggested analyzing for tracers or indicator substances, rather than for the broader range of hazardous components that could be in a waste. Cost was cited as a reason for this suggestion. Lack of sufficient analytical capacity and procedures was also mentioned. It was suggested that due to waste degradation, the form of chemical components might change, making it uncertain what actual hazardous constituents were present.

The Agency does not agree that there is a lack of analytical capacity and procedures to carry out a comprehensive analysis. No evidence was presented to support that contention, and the experience of the Agency strongly suggests that this is not the case.

Concerning degradation byproducts, the Agency had decided that the owner or operator will have to know or predict what degradation byproducts will be formed as a result of land treatment. Section 122.25(d) requires the owner or operator to define the hazardous waste(s) that will be land treated and predict the mass rate of hazardous waste and decomposition byproducts that are expected to leach or otherwise escape from the site.

Use of indicator substances does have merit from a cost and simplicity standpoint. Conceptually, if one could select a substance

47

in the waste which was known to migrate in the soil at least as rapidly as any other substances in the waste, then it could be monitored as an indicator. If that substance was detected as having migrated, then a more comprehensive analysis for other substances should be carried out. During the permitting process, an owner or operator will have the opportunity to supply data to the Agency supporting the use of indicator substances in lieu of repeated comprehensive analyses.

The issues of soil-core depth and corrective action are discussed together since they are closely related. In the regulations it was proposed that soil cores be taken to a depth of three times the zone of incorporation. If migration of contaminants was detected, as indicated by an increase in waste constituents over background levels in the bottom one-third of the core, then the owner or operator was to cease operation in the affected area, notify the Regional Administrator, and determine corrective action.

Some commenters objected to the monitoring depth of three times the zone of incorporation as being less desirable than a fixed core depth. Three feet was suggested. It was argued that depth of tillage was not relevant in determining environmental performance. In contrast, several commenters felt the support for the proposed monitoring depth was appropriate.

The proposed monitoring depth was criticized for the corrective action required if migration to that depth occurred. Commenters argued that the fact that migration to the specified depth had occurred was not an indication of actual or potential environmental damage, and that the corrective action proposed was excessive.

50

In consideration of the comments received on soil monitoring, and upon further analysis of the alternatives available the Agency has revised its approach to monitoring the environmental performance of land treatment facilities. The environmentally sensitive nature of land treatment requires the owner or operator to have an accurate picture of the movement of contaminants in the unsaturated zone. EPA has decided that such an objective requires a more comprehensive monitoring plan than was proposed. The new plan will require soil monitoring, using soil cores, and in addition, the owner or operator will be required to monitor the soil-pore water, using lysimeters or similar devices. This new monitoring scheme, now called "unsaturated zone (zone of aeration) monitoring", although requiring an additional type of monitoring, is structured so that it will provide the owner or operator with the flexibility necessary to develop a site-specific monitoring plan.

Although lysimeter monitoring was not proposed in December 1978, it is necessary, because, as commenters pointed out, soil monitoring will not detect rapidly migrating waste constituents. Given the comments on contaminant migration, and indications from an EPA-sponsored study that some organic compounds are apparently capable of rapid migration (29), it is evident that soil monitoring may not adequately detect contaminant migration and that soil-pore water monitoring may also be needed. The need for more comprehensive monitoring is further justified by the fact that land treatment facilities characteristically lack liners.

Unlike landfills and surface impoundments the use of lysimeters or similar devices is feasible at land treatment sites. Lysimeters

(5)

can be installed at land treatment facilities in the area where waste has been applied. This is not practical for existing surface impoundments and landfills. In addition, the relatively shallow depth of waste application at land treatment facilities permits lysimeters to be replaced at both existing and new facilities, when they become clogged or otherwise nonfunctional. Furthermore, land treatment facilities do not have artificial liners which would interfere with the placement of lysimeters. The advantage of monitoring soil-pore water is that this type of monitoring will detect contaminants passing through the soil, whereas soil monitoring does not detect what passes through, but what has been left behind. The timing of soil-pore water sampling is very important. The sample(s) must be taken when soil-pore water from waste application is present in the sampling device. This is a function of when the waste is applied, the water content of the waste, precipitation, soil permeability, and depth of the lysimeter.

Soil-pore water monitoring in combination with soil and ground-water monitoring will provide comprehensive knowledge about the performance of the facility and its ability to protect ground water. This monitoring approach will also provide information on the mass balance (i.e., location, distribution, concentration) of contaminants in the unsaturated zone. This type of information is not only necessary from a regulatory (environmental performance) standpoint, but is requisite to understanding how a land treatment system functions. Using the monitoring data as feedback on the performance of a site, an owner or operator can more effectively manipulate operating variables in order to optimize the performance of the

site (e.g., waste application rates, tilling frequency, and pH controls).

The regulations for unsaturated zone monitoring are structured, as discussed previously, to provide the owner or operator with the flexibility necessary to design a monitoring program which takes into account site-specific factors. The regulation includes a list of factors and relationships that must be taken into account when developing the plan. The owner or operator must maintain all data collected and make it available for review upon request by the Regional Administrator, and must submit all the data in conjunction with Part B of the application for a permit in accordance with Section 122, Subparts A and B. The unsaturated zone monitoring information will be particularly useful in developing the closure and post-closure care plans. This approach is intended to accommodate inherent differences between sites, and stimulate innovation of more efficient monitoring methods and plans.

(3) Summary

The Agency has revised the monitoring requirements at hazardous waste land treatment facilities. Because of concerns raised by some commenters over the inability of soil monitoring to detect highly mobile contaminants, the Agency has decided to require ground-water monitoring at land treatment facilities. Further impetus for ground-water monitoring came from the need for a more clear determination of what constitutes contamination at a land treatment facility. Additionally, the Agency needed a mechanism for evaluating the total impact that land treatment facilities have on the environment. This evaluation is considered necessary

(53)

in light of the fact that land treatment facilities are expected to result in the discharge of leachate to ground water.

Significant changes were made to the proposed soil monitoring regulations in response to both public and in-house comments. The proposed soil monitoring scheme has been replaced with a more comprehensive unsaturated zone monitoring scheme. Soil-pore water monitoring, using lysimeters or similar devices is required in addition to soil monitoring. Although the new scheme is more comprehensive than the proposed regulations, it is structured to give the owner or operator the flexibility necessary to develop a site-specific monitoring plan.

D. Regulatory Language

(a) The owner or operator must have in writing, and must implement, an unsaturated zone monitoring plan which is designed to characterize the leachate that is expected to leave the zone of incorporation and substantiate the predictions made under §§122.25(d)(2) and (3) and 122.28(f)

(b) The unsaturated zone monitoring plan must include, at a minimum:

- (1) Soil monitoring using soil cores, and
- (2) Soil-pore water monitoring using devices such as lysimeters.

(c) To comply with paragraph (a)(1) of this Section, the owner or operator must demonstrate in his unsaturated zone monitoring plan that:

- (1) The depth at which soil and soil-pore water samples are to be taken is below the zone of incorporation.

(2) The number of soil and soil-pore water samples to be taken is based on the variability of:

(i) The leachate expected to leave the zone of incorporation; and

(ii) The earth materials above the zone of saturation; and

(3) The frequency and timing of soil and soil-pore water sampling is based on the frequency, time, and rate of waste application, proximity to ground water, and soil permeability.

(d) The owner or operator must keep at the facility his unsaturated zone monitoring plan, and the rationale used in developing this plan.

(e) The owner or operator must analyze the soil and soil-pore water samples and compare the results to the predictions required under §§122.25(d)(2) and (3) and 122.28(f).

6. Recordkeeping - §264.279

A. Proposed Regulations and Rationale

The regulations proposed in December 1978 included recordkeeping and reporting requirements applicable to all treatment, storage, and disposal facilities, including land treatment. The requirements included: an operating log, a record of the quantity and description of each waste received, locations in the facility where each waste was treated or disposed and methods and dates of treatment or disposal, the results of the waste analysis performed, monitoring data, reports of visual inspections, and records of incidents requiring initiation of a contingency plan.

The rationale for these requirements was presented in the Part 265 Background Document dealing with the Manifest System,

Recordkeeping, and Reporting requirements of the interim status regulations.

B. Summary of Comments

Comments on the proposed recordkeeping and reporting requirements are discussed in the Part 265 Background Document on the Manifest System, Recordkeeping and Reporting.

C. Discussion

In structuring the Part 265 interim status regulations and the Part 264 proposed regulations, Agency has elected to include some of the proposed recordkeeping requirements of December 1978 in the sections of the regulations which address specific types of facilities. Such recordkeeping is needed in Subpart N to allow the owner or operator and the Regional Administrator to evaluate compliance with specific requirements for land treatment.

For land treatment facilities, recordkeeping requirements have been incorporated relative to the location where each different waste is placed in the facility, when it was placed there, and at what rate. This information will assist, through the use of mass-balance analysis, in substantiating predictions made about leachate migration through the unsaturated zone. The Agency believes that these requirements are an integral part of facility operations. These records may be needed to assist the owner or operator in emergency situations or enforcement officials who may be called upon to investigate problems. In most cases such recordkeeping will be routinely performed to satisfy or supplement monitoring and closure requirements.

The recordkeeping requirements for land treatment facilities

are not expected to be burdensome since the types of waste and treatment areas are typically limited at any one land treatment facility.

Additional recordkeeping requirements relative to results obtained from unsaturated zone monitoring, food-chain crop testing or monitoring, and monitoring or analysis carried out under the closure plan are specified elsewhere. The owner or operator is required to place all such data and information in the operating record of the facility. A discussion of the facility operating record and the rationale for the inclusion of the data and information specified is discussed in the Part 265 Background Document on Manifest System, Recordkeeping and Reporting.

D. Regulatory Language

The owner or operator of a land treatment facility must keep records of the application dates, application rates, quantities, and location of each hazardous waste placed in the facility, in the operating record required in §264.73.

7. Closure and post-closure - §264.280

A. Proposed Regulations and Rationale

The proposed regulations provided two basic options for closure of a land treatment facility. One option was to return the soil in the treated area to its preexisting condition, as determined by background soil analysis or analysis of similar local soils. The other option was to remove the contaminated soil from the facility if that soil met the characteristics of a hazardous waste. (If it did not fail the hazardous waste characteristics, no further action was required.) However, a variance to the second option

(52)

permitted the facility to be closed as a landfill if the owner or operator could demonstrate that the design or location provided long-term integrity and environmental protection equivalent to a landfill, as specified in the proposed regulations.

One objective of the requirement to return the soil to its preexisting condition or remove it, was to prevent the conversion of huge tracts of productive land to land having limited potential for future use. In addition, the Agency has limited data on the fate and long-term effects of the hazardous contaminants in a land treatment facility. There was concern that the contaminants would eventually be carried away by surface runoff or would migrate to ground water.

There was some precedent in state regulations for the proposed approach. The Texas Department of Natural Resources incorporates a similar approach in some of the permits issued for land treatment facilities. If the results of tests comparing the leachate from treated soil with untreated soil suggest a potential threat of hazard to surface water, the Texas Department of Natural Resources requires the removal of soil to a depth of 12 inches.

The variance for closure as a landfill was based on the assumption that if appropriate liners, monitoring, and cover were provided, the facility would not present a significant potential for environmental damage. While this and the other closure options take a conservative posture on closure, the Agency felt that it had no information to suggest that other approaches would be protective. This is due to the fact that, to the knowledge of EPA, no hazardous waste land treatment facility has been closed to date.

5

B. Summary of Comments

(1) Return of soil to preexisting condition

- ° Requiring return of soil to its original condition is beyond RCRA authority. There is nothing in RCRA or its legislative history to support this requirement.
- ° Land treatment may improve some soils, so return to original condition would be considered counterproductive.
- ° Requiring that land be returned to its original condition is unreasonable, impractical, and prohibitively expensive and will eliminate land treatment.
- ° The regulations should consider return to productive use, i.e., capable of supporting indigenous vegetation.
- ° The term "preexisting conditions" is vague and indefinite, and the regulations fail to establish standards by which the condition of the land upon closure may be established.
- ° Return to original soil condition is unnecessary because land treatment facilities can be returned to productive use as long as levels of contaminants in the soil are not a problem for those uses, and the amount of land used or contemplated is not a significant portion of productive land.
- ° Requiring return of the soil to its preexisting condition discriminates against industry, since land treatment of POTW sludges has no such restrictions.

(2) Use of the Extraction Procedure* (EP) on soil

- ° The EP may not appropriately identify contaminated soil. It will underestimate the contamination of the soil, since it does not test for all hazardous contaminants, only those in the EPA Drinking Water Standards.
- ° The decision to remove soil should include factors such as: the chemical and physical characteristics of the contaminants, the soil's ability to support vegetation, the potential for erosion, the site location, and the intended future use of the land.
- ° The EP is not appropriate for clay soils, which often contain cadmium and selenium in their natural state. Thus, the EP may show virgin soil to be hazardous.

*The Extraction Procedure is described in §250.13(d) of Subpart A in the December 19, 1978, proposed regulations.

(59)

- ° Should use water rather than the acid in the soil EP because water is the "natural leachant" [sic] from precipitation and runoff.
- ° Naturally-occurring soils would fail the EP (data not provided).

(3) Soil removal: closure as a landfill.

- ° The potential expense of removal of soil or closure as a landfill is extreme and would create a serious threat to land treatment of industrial wastes.
- ° To remove and landfill the soil in a land treatment facility would so increase the overall cost of land treatment that it would become economically noncompetitive with a landfill or other disposal options. This would eliminate land treatment as a disposal method. (No data provided.)
- ° The removal of soil can result in problems of accelerated erosion that would negate any questionable advantage of removal.

(4) Suggested alternative closure requirements.

- ° Soil should be allowed to remain only when soil erosion is negligible for 50 to 100 years and an impermeable soil structure exists.
- ° Closure regulations should specify the objective of closure, when it should begin, and certain minimum conditions. Determination of when closure should begin should be based on waste characteristics and soil properties, particularly assimilation capacity. It is recommended that closure regulations require:
 - closure so that no further maintenance is necessary
 - treating the soil to achieve a pH of 6.5 (minimum)
 - vegetative cover
 - control of erosion; maintenance of dikes
 - removal of any soil incapable of supporting vegetation or which presents a threat to human health and the environment
- ° Should consider specifying pH maintenance and other "onsite" measures to prevent migration.

- ° Should require only soil monitoring for closure because return to original condition is too difficult, and removal would not eliminate the disposal problem. Additional protection could be provided by the type of soil and the berm around the treated area.
- ° Should not look at the increase of contaminants in the soil, but whether the soil presents a hazard to ground water or whether crops grown on the soil would have dangerously elevated concentrations.
- ° Closure should relate to the level of potential environmental harm.
- ° Closure should require prevention of escape of metals by runoff, plant uptake, or wind.
- ° Should leave closure design criteria to the owner or operator, since proper design is site-specific.
- ° It is not true that, left unattended, contaminants of the soil filter media will eventually be carried off by surface runoff or will migrate to ground water. It is also not true that such occurrences will be significant, especially if plant cover is established. Under some conditions, soil should be left as it is.
- ° EPA's position for soil removal is inconsistent since EPA admits no documented cases of ground-water contamination, yet says that if soil is left unattended, contaminants will eventually migrate.

C. Discussion

(1) Return of soil to preexisting condition.

The Agency agrees with many of the points made by commenters and has removed this requirement from the final regulations. There was a strong consensus in the comments that such a requirement was impractical and would effectively terminate land treatment as a waste management option. Furthermore, the Agency was unable to identify methods of returning soil to its preexisting condition, or to adequately define how the Agency would judge whether this has been achieved. The Agency also concluded that this was not a necessary condition for future productive use of the land. Finally,

and most importantly, the Agency believes that alternative closure requirements which are more practical can achieve protection of the environment.

(2) Use of the Extraction Procedure (EP) on soil.

The proposed regulations referred to the extraction procedure (EP), defined in Subpart A of the proposed regulations, as the method to determine if soils in a land treatment facility are hazardous at the time of closure. If the EP showed the soil to be hazardous then the owner or operator was to close the site by either removing the contaminated soil or closing the site as a landfill.

Comments on the use of the EP suggested it was inappropriate, but for diametrically opposite reasons. Some commenters felt the EP would underestimate contamination because it covered only a few contaminants, while other commenters felt the EP would overestimate the contamination of the soil because it was too harsh an extractant.

Two commenters expressed concern that the EP would show certain virgin soils to be hazardous. No data was provided to corroborate the comments.

Based upon the comments and a reevaluation of its position, the Agency found that the EP, as proposed in Subpart A, is not appropriate as the sole indicator of whether the soil should be removed or the facility should be closed like a landfill.

The Agency considered alternative soil tests, but was unable to identify any which had both broad application and the ability to unequivocally indicate that the soil of a land treatment facility is contaminated to the extent it would need to be removed.

102

The major drawback of using a simple soil test is that it does not take into account the various extrinsic factors that play an integral role in determining the hazard posed by the soil. This point was made in the comments. One commenter suggested that the decision to remove the soil of a land treatment facility should include factors other than the EP results. The following factors were identified: chemical and physical characteristics of the contaminants, the soil's ability to support vegetation, the potential to support vegetation, the potential for erosion, site location, and intended future use of the land.

The Agency has decided to use an approach similar to the one suggested in the comments. The Agency has identified four environmental objectives and a number of factors that the owner or operator of a land treatment facility should consider to meet the objectives, when deciding on the disposition of the soil from the active portion(s) of the site. A detailed discussion is presented under item (4) below.

(3) Waste removal: closure as a landfill.

Although most of the closure comments focused on return of the soil to its preexisting condition, a few comments addressed waste removal and closure as a landfill. The tenor of these comments was that these requirements would be too costly and would make land treatment noncompetitive. No data were provided to support these claims.

The Agency agrees that these proposed closure options will result in increased costs for land treatment. However, the contention that land treatment will become noncompetitive as a

(62)

result of cost is not tenable. The cost of all waste management practices will increase as a result of the Subtitle C regulations, and the Agency expects land treatment to remain a viable waste management option for certain waste streams. Additionally, it is not the objective of the closure regulations to ensure that land treatment remains competitive, in the economic sense. Rather, the objective is to ensure that the closure requirements prevent the uncontrollable release of contaminants into the environment.

The real issue is whether there is a need for such a restrictive approach. Because of the dearth of information available on closing land treatment facilities, and the relatively young age of this waste management practice, the Agency has not been able to unequivocally demonstrate the need for such a restrictive and rigid closure approach. As a result, the Agency has removed these closure requirements from the final regulations in favor of a more flexible approach, described below.

(4) Alternative closure approaches

A number of alternative closure approaches were suggested in the comments. Many of these approaches may have merit in a given situation. Most depend on a case-by-case assessment.

The Agency believes that it is both feasible and desirable to base the closure requirements on such individual assessments. The owner or operator should be allowed to make a case that a given closure procedure will suit his particular situation and provide adequate environmental protection. This type of approach is necessary because of the current lack of experience with land treatment facility closure and the consequent lack of a data base

64

to adequately support particular closure requirements.

Therefore, the Agency has substantially revised the closure requirements for land treatment facilities. The new requirements specify that the owner or operator must develop and implement a facility closure plan. The terms of that plan are enforceable against the owner or operator. The plan must address four objectives:

- ° controlling the migration of leachate from the zone of incorporation into ground water;
- ° controlling the release of contaminated runoff to surface water;
- ° controlling the release of airborne particulate contaminants; and
- ° compliance with the standards established for food-chain crops.

In meeting these objectives the owner or operator must consider a range of factors affecting the facility's ability to meet the objectives. Relative to ground-water protection, these factors include: depth to ground water; ground-water use; geological profile; amount and acidity of precipitation; type, concentration, and extent of migration of leachate in the soil; expected rate of leachate migration including any data from laboratory leaching studies using the soil in the facility; soil characteristics, including cation exchange capacity, total organic carbon, and pH; feasibility of removing the contaminated soil at a later time if migration continues and appears likely to contaminate ground water; comprehensiveness of proposed monitoring following closure; and

proposed post-closure care, including maintenance of unsaturated zone monitoring, restricting site access, and future land use.

Relative to surface water protection, the factors include: surrounding geography and land use, surrounding surface water uses and quality, amount and acidity of rainfall, use of cover or vegetation to minimize erosion of contaminated soil, maintenance of diversion structures to prevent surface runoff from entering the active portion(s), structures for collecting and treating any runoff, etc..

Regarding wind erosion, the Regional Administrator will evaluate the use of vegetation or cover to prevent soil erosion and control the release of airborne particulate contaminants.

The owner or operator must also develop a post-closure care plan. The terms of this plan are also enforceable against the owner or operator. Under these regulations the post-closure care plan must provide for maintenance of monitoring systems, restriction of access as appropriate for post-closure use, and control of the growth of food-chain crops to the same degree as required for an active facility.

D. Regulatory Language

(a) In the closure plan under §265.112 and the post-closure plan under §265.118, the owner or operator must address the following objectives and indicate how they will be achieved:

(1) Control of the migration of leachate from the zone of incorporation into the ground water;

(2) Control of the release of contaminated run-off from the facility into surface water;

(3) Control of the release of airborne particulate contaminants caused by wind erosion; and

(4) Compliance with §264.276 concerning the growth of food-chain crops.

(b) The owner or operator must consider at least the following factors in addressing the closure and post-closure care objectives of paragraph (a) of this Section:

(1) Type and amount of hazardous waste applied to the land treatment facility;

(2) The mobility and the expected rate and amount of migration of the leachate zone of incorporation;

(3) Site location, topography, and surrounding land use, with respect to the potential effects of pollutant migration (e.g., proximity to ground water, surface water and drinking water sources);

(4) diversion structures to prevent surface water run-on from entering the treated area; and

(5) Monitoring of soil, soil-pore water, and ground water.

(d) In addition to the requirements of §264.117, during the post-closure care period, the owner or operator of a land treatment facility must:

(1) Maintain any unsaturated zone monitoring system, and collect and analyze samples from this system in a manner and frequency specified in the post-closure plan;

(2) Restrict access to the facility as appropriate for its post-closure use; and

(3) Assure that growth of food chain crops complies with §264.276.

(e) For the purpose of complying with §264.115, when closure is completed, the owner or operator of a land treatment facility must submit to the Regional Administrator certification both by the owner or operator and by a qualified engineer or by a qualified soil scientist that the facility has been closed in accordance with the specifications in the approved closure plan.

3. Special requirements for:

ignitable or reactive wastes - §264.281;

and incompatible wastes - §264.282

A. Proposed Regulations and Rationale

The proposed regulations prohibited placing ignitable, reactive, volatile, and incompatible wastes in a land treatment facility, but allowed a variance if the owner or operator can demonstrate that airborne contaminants would not exceed a specified concentration, and that the attenuation capacity of the facility would not be adversely affected through heat generation, fires, or explosions.

The objective of the proposed regulation was to prevent damages to human health and the environment which could result from fires or explosions in a land treatment facility. Placing ignitable or reactive wastes in a land treatment facility presents at least two potential problems.

One problem is the contamination of the air through volatilization, since most ignitable and some reactive wastes have relatively high vapor pressures. A second problem is that ignitable and reactive wastes can explode or burn easily, injuring the personnel at the facility and releasing toxic fumes that can reach surrounding populations and cause personal and property damage.

Fires and explosions can also adversely affect the attenuation capacity of the facility.

A recent study (3) has shown that, during land treatment operations, fires and explosions can occur. Potential ignition sources include electrical sparks from machinery operating on the facility, accidents or errors such as smoking near the facility, and extreme heat generation from reactive or incompatible sources.

Mixing of hazardous wastes that are not compatible with each other in a hazardous waste land treatment facility can result in similar types of environmental problems. Such mixing can cause fires and explosions, excessive heat generation, or generation of toxic gases. This could endanger facility personnel or populations in the vicinity of the facility, or it could adversely affect the attenuation capacity of the facility.

B. Summary of Comments

The restrictions on ignitable, reactive, and incompatible wastes in the proposed regulations went beyond land treatment. Similar restrictions were included in the proposed regulations for all treatment and disposal facilities under §265.22, and standards for basins under §250.45-5. The background documents dealing with those standards contain additional analysis of comments on this issue.

Those comments directed specifically toward land treatment facilities are as follows:

- ° The restriction on ignitables should be revised to allow land treatment if the waste is no longer ignitable after incorporation into the soil.

- ° Many hazardous wastes classified as ignitable or reactive, or which are incompatible when combined, may lose these properties when mixed with the soil due to dilution, adsorption, or other mechanisms. Thus land treatment of such wastes should not be prohibited.
- ° A land treatment facility can act as a destruction mechanism, rendering a waste nonhazardous through slow oxidation. Ignitable, nitrated organics are particularly amenable to slow oxidation in soils. This would be a safer disposal method than rapid oxidation through incineration. The hazard of most concern is placing the material without incident during handling. An absolute prohibition against land treatment of ignitables, reactives, or incompatibles in any concentrations or quantities is inappropriate.
- ° Land treatment is an attractive way to dispose of hazardous oily wastes. The exclusion of land treatment of ignitables should be lifted. This can be done safely with little or no fire hazard.
- ° The proposed regulations will preclude land treatment as a viable alternative, since many wastes are ignitable, reactive, or volatile, and corrosive wastes cannot be land treated due to pH. The variance is not likely to be viewed favorably by permit officials.

C. Discussion

Relevant to the discussion of the comments above is the fact that the Agency is now planning to consider air emissions in the permit issuance process. For discussion related to comments on the variance in §250.45(c) dealing with volatility, the reader is referred to the Background Document No. 8 - Ground-water and Air Emission Monitoring.

The comments on ignitable waste suggest that incorporation of such wastes into the soil is, in itself, an effective way of rendering these wastes non-ignitable. The Agency concurs with this suggestion. However, as a comment suggested, the safety of handling the waste, i.e., incorporating it into the soil, is still an issue. However, the Agency has no damage cases indicating that this has

70

been a problem in practice up to this time. Nevertheless, one way of eliminating or reducing this handling hazard would be to treat or mix the waste prior to land treatment, so that the resulting material is no longer ignitable. This practice would provide the greatest margin of safety.

A similar logic would apply to land treatment of reactive or incompatible wastes. In an attempt to find a method of rendering such wastes nonreactive, the Army Material Development Command, at Edgewood Arsenal in Natick, Massachusetts has safely land-treated reactive wastes (30). While other characteristics of the particular waste, (i.e., nonbiodegradability), reduced the attractiveness of land treatment, safe handling, and rendering the wastes non-reactive did seem possible.

In view of these considerations, the regulations have been revised to include conditions under which such wastes can be land treated.

D. Regulatory Language

§265.281 Special requirements for ignitable or reactive waste

Ignitable or reactive wastes must not be land treated, unless:

(a) the waste is immediately incorporated into the soil so that (1) the resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under §§261.21 or 261.23 of this chapter, and (2) §264.17(b) is complied with; or

(b) The waste is managed in such a way that it is protected from any material or conditions which may cause it to ignite or react.

(74)

§265.282 Special requirements for incompatible wastes

Incompatible wastes, or incompatible wastes and materials, (see Appendix V for examples) must not be placed in the same land treatment area, unless §264.17(b) is complied with.

9. Special requirements for Classes of Facilities - §264.283

A. Proposed Regulations and Rationale

The proposed regulations required that the zone of incorporation of a land treatment facility be a maximum of 1.5 meters above the historical high water table. The land treatment facility could be less than 1.5 meters if the owner or operator could demonstrate that no direct contact would occur between the zone of incorporation and the water table.

The purpose of this standard was to ensure that sufficient distance exists between the zone of (waste) incorporation and the high water table. Direct contact between the zone of incorporation and the water table for a prolonged period of time increases the likelihood that wastes will escape to the environment. Direct contact will preclude the existence of an unsaturated zone. The process of attenuation, upon which a land treatment facility depends, cannot function properly under saturated conditions.

An unsaturated zone is needed to provide space for unsaturated zone monitoring and to compensate for fluctuations in the height of the water table during its yearly hydrological cycle.

B. Summary of Comments

- ° The 1.5 m requirement should be relaxed for land treatment facilities located over non-underground drinking water sources, e.g., salt or brackish ground water, otherwise coastal areas of the U.S. will be out of consideration as land treatment sites.

72

- ° Specification of 1.5 m is too specific for land treatment disposal operations. Actual rules for a disposal site should be based upon the geology and the material being land treated.
- ° A 1.5 m separation is inadequate from the standpoint of protecting public health and the environment. Site preparation and unforeseen site characteristics may encourage vertical migration of contaminated soil water.
- ° The utility industry had two opinions. Two commenters felt the requirement was too stringent and would preclude landfarming of flyash and sludge in coastal areas. Another commenter, although agreeing in principle with the other two commenters, felt the variance to the regulation made it acceptable, provided the Regional Administrator would accept a showing based on readily-available historical information as an adequate demonstration that no direct contact will occur.

C. Discussion

Although this standard was not included in the Part 265 land treatment interim status standards, it is included in Part 264. The new standard requires a two meter separation between the incorporated waste and the aquifer being or to be used, (i.e., the historical high water table for water table aquifers, or the bottom of the confining soils for artesian aquifers).

This standard is considered necessary by the Agency because of the nature of land treatment facilities, i.e., the reliance on attenuation of contaminants in the unsaturated zone; and to ensure that unsaturated zone monitoring can be achieved. The Agency acknowledges that a land treatment facility might be able to operate safely with less than two meters from a usable aquifer however the basic purpose of technique (e.g., biological and chemical treatment) would be interfered with, and that, along with the loss of the capability to monitor performance by soil-pore (zone of aeration) monitoring, does not warrant regulatory flexibility.

D. Regulatory Language

A Class C, D, or E land treatment facility must have a minimum of two meters between the incorporated waste and the aquifer being or to be used, (i.e., the historical high water table for water table aquifers, or the bottom of the confining soils for artesian aquifer).

III. REFERENCES

1. U.S. Environmental Protection Agency. Report to Congress: Waste Oil Study, April 1974.
2. Kincannon, C.B., Oily Waste Disposal by Soil Cultivation Process EPA-R2-72-100, U.S. Environmental Protection Agency, December 1972.
3. SCS Engineers. Land Cultivation of Industrial Wastes and Municipal Solid Wastes: State of the Art Study. Volume 1. Contract No. 68-01-2435, U.S. Environmental Protection Agency, August 1978.
4. Phung, H.T., D.E. Ross, and R.E. Landreth. Land Cultivation of Industrial Wastewater and Sludges. Proc. National Conference on Treatment and Disposal of Industrial Wastewaters and Residues. 1977 (in press).
5. Raymond, R.L., J.O. Hudson, and V.W. Jamison. Oil Degradation in Soil. Applied and Environmental Microbiology, 31:4, 522-535. April 1976.
6. Healy, W.B., Ingested Soil and Animal Nutrition, pp. 84-90. In Proceedings of the New Zealand Grassland Association, 34, 1972.
7. Letter from R. L. Chaney, USDA Plant Physiologist, submitted to EPA as comments on Proposed Criteria for Classification of Solid Waste Disposal Facilities and Practices, May 12, 1978.
8. Jelinek, C.F., G.L. Braude, and R.B. Read, Jr., Management of Sludge Use on Land, FDA Considerations, presented at Association of Metropolitan Sewerage Agencies conference on Sludge Management, Houston, Texas, April 13, 1976.
9. Healy, W.B., Ingestion of Soil by Dairy Cows, New Zealand Journal of Agricultural Research, Vol. 11, No. 2, 1968, p. 498.
10. U.S. Environmental Protection Agency, Land Cultivation of Industrial Wastes and Municipal Solid Wastes: State of the Art Study, Volume II, 1978, 157 p.

11. Bergh, A.K., and R.S. Peoples, Distribution of Polychlorinated Biphenyls in a Municipal Wastewater Treatment Plant and Environs, The Science of the Total Environment, 1977.
12. Personal communication with Dr. P. Kearney, USDA, Beltsville, Maryland.
13. Personal communication with Dr. A.M. Decker, University of Maryland, College Park, Maryland.
14. Harrison, D.L., J.C.M. Mol, and W.B. Healy. New Zealand Journal of Agricultural Research, 13, pp. 664-672.
15. Personal communication with Dr. G. Fries, USDA, Beltsville, Maryland.
16. Chaney, R.L. and P.M. Giordano. Microelements as Related to Plant Deficiencies and Toxicities, pp. 235-279. In L.F. Elliott and F.J. Stevenson (ed.), Soil Science Society of America, Madison, Wisconsin, 1977.
17. Chaney, R.L., and C.A. Lloyd, Adherence of Spray-Applied, Liquid, Digested Sewage Sludge to Tall Fescue, submitted to EPA as comments on Proposed Criteria for Classification of Solid Waste Disposal Facilities and Practices.
18. Jones, S.G., K.W. Brown, L.E. Deuel, and K.C. Donnelly, Influence of Simulated Rainfall on the Retention of Sludge Heavy Metals by the Leaves of Forage Crops, Journal of Environmental Quality, Vol. 8, No. 1, 1979, p. 69.
19. Allaway, W.H., "Food Chain Aspects of the Use of Organic Residues," pp. 282-298. In L.F. Elliot and F.J. Stevenson (ed.) Soils for Management of Organic Wastes and Wastewaters, Soil Science Society of American, Madison, Wisconsin, 1977
20. Kardos, L.T., C.E. Scarsbrook, and V.V. Volk, Recycling Elements in Wastes through Soil - Plant Systems, pp. 330-324. In L.F. Elliot and F.J. Stevenson (ed.), Soils for Management of Organic Wastes and Wastewaters, Soil Science Society of America, Madison, Wisconsin, 1977.
22. Kirkham, M.B., Trace Elements in Sludge on Land: Effect on Plants, Soils, and Ground Water, pp. 209-247. In R.C. Loehr (ed.), Land as a Waste Management Alternative, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1977.
23. U.S. Environmental Protection Agency, Reviews of the Environmental Effects of Pollutants: VII Lead, 1979.
21. U.S. Environmental Protection Agency. Sludge Treatment and Disposal, Volume 2, 1978, 155 p.

24. Pahren, H.R., J.B. Lucas, J.A. Ryan, and G.K. Dotson, An Appraisal of the Relative Health Risks Associated with Land Application of Municipal Sludge, presented at 50th Annual Conference of the Water Pollution Control Federation, 1977.
25. Iwata, Y., et al. Uptake of PCB (Aroclor 1254) from Soil by Carrots under Field Conditions, Bulletin of Environmental Contamination and Toxicity, Volume 2, 1974.
26. Elfuing, D.C., Hascheck, W.M., Stehn, R.A., Bache, C.A. and Lisk, D.J. Heavy Metal Residues in Plants Cultivated on and in Small Mammals Indigenous to Old Orchard Soil. Archives of Environmental Health, 33(2), 95-99 (1978).
27. Page, A.L., Fate and Effects of Trace Elements in Sewage Sludge When Applied to Agricultural Lands. A Literature Review Study. EPA-670/2-74-005, U.S. Environmental Protection Agency, January 1974.
28. Meyers, J.D., and R. L. Huddleston, Treatment of Oily Refinery Wastes by Landfarming. For presentation at the 34th Annual Purdue Industrial Waste Conference, May 8-10, 1979.
29. Personnel communication with Dr. Kirk Brown, Texas A&M University. College Station, Texas, January 24, 1980
30. Personal communication. George Marienthal, Department of Defense, Washington, D.C., to L.A. Weiner, Office of Solid Waste. October 19, 1977.